U.S. FOREST SERVICE
RESEARCH NOTE RM -10

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Effects of Rock Mulch and Scalping on Survival of Planted Ponderosa Pine in the Southwest[1]

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Regeneration is one of the most difficult phases of management of ponderosa pine (Pinus ponderosa Laws.) in the Southwest. Both natural and artificial reforestation measures have frequently been unsuccessful. Although many factors are involved in the failures, the one considered to be most important is lack of precipitation during the spring. The dry period usually occurs in May and June, but may extend from early May to late July. In many areas, dense stands of perennial grasses take the available soil moisture that might be used by pine seedlings or transplants during the dry period (Pearson, 1942).

Figure 1.-- Deep-planted ponderosa pine transplant with three-rock mulch.

1/ Research reported here was conducted at Flagstaff in cooperation with Arizona State College and the Coconino National Forest.

2/ Research Forester, located at the Station's project headquarters at Flagstaff in cooperation with Arizona State College; central headquarters are maintained at Fort Collins in cooperation with Colorado State University.

This progress report describes some methods used to conserve soil moisture at two recent plantations at Arizona.

THE STUDY

In the early spring of 1960, 1,280 ponderosa pine transplants (2-1) were planted at A-1 Mountain west of Flagstaff, Arizona, and 9,600 were planted at Jones Mountain south of Flagstaff. The Jones Mountain site had been burned by wildfire in the spring of 1959 and immediately seeded with a mixture of grasses. The plantation is on a fairly uniform slope with a southeasterly aspect. The soil is fairly deep but with outcroppings of rock throughout the area. A barbed wire fence was built around the entire plantation to exclude domestic livestock but not wildlife.

The study at Jones Mountain was designed to test four methods of planting. No site preparation was done because vegetation was sparse at planting time. The study consisted of four replications of four randomized treatment plots. In each plot, 600 trees were planted at a spacing of 6 by 6 feet by one of the following planting methods:

1. Standard depth--tree set in ground up to the root collar.
2. Standard depth with three-rock mulch--three nearly flat rocks, approximately 6 to 8 inches in diameter, placed around the tree stem (Rotty, 1958).
3. Deep planting--trees set in ground to the terminal bud.
4. Deep planting with three-rock mulch (fig. 1).

In each plot, 100 trees were randomly selected at the start of the study to be checked for survival. All the trees were sprayed with a 10-percent solution of TMTD (tetramethylthiuramdisulfide) to reduce browsing by deer and elk (Heidmann, 1962).

The plantation at A-1 Mountain was located on a 10-year-old burn. Several attempts to plant the site had failed mainly because of competing vegetation, and browsing and trampling by cattle and deer. The aspect is easterly with a gentle slope. A deer- and cattle-proof fence surrounds the plantation. The ground cover is a mixture of weed species and perennial grasses, mainly mountain muhly (Muhlenbergia montana (Nutt.) Hitchc.) and Arizona fescue (Festuca arizonica Vasey).

The A-1 Mountain study, designed to test four degrees of mechanical site preparation and four planting methods, consisted of eight replications of four plots (15 by 33 feet). Each plot received one of the following four scalping treatments:

1. None--check plot.
2. Scalped spots 16 inches in diameter.
3. Scalped spots 26 inches in diameter.
4. Complete scalping--entire plot scalped.

Forty trees, (10 planted by each of the four planting methods used at Jones Mountain) were planted on each plot.

RESULTS

Survival by the four methods of planting was as follows after two growing seasons:

	Percent
Standard depth - mulched	68
Standard depth - no mulch	64
Deep planting - no mulch	58
Deep planting - mulched	56

Differences in survival were not significant. Over half the mortality during the first 2 years at Jones Mountain was caused by drought; most losses occurred during the first summer (table 1). Approximately 21 percent of total mortality occurred the first winter and was assumed to be winterkill (excessive desiccation of the plant tissues during the winter when tips were exposed to drying winds and the soil was frozen). About 15 percent of the losses were attributed to poor physiological condition of the trees--inability to produce new roots after field planting (Stone, 1955). Very little mortality resulted from animals or from frost heaving, which at times may be quite serious. Although deer and elk had browsed 21 to 25 percent of the trees during the 2 years, few were killed directly by browsing.

Table 1. --Causes of mortality at Jones Mountain and A-1 Mountain after two growing seasons

Causes of mortality	Jones Mountain		A-1 Mountain	
	Proportion of trees in sample[1]	Proportion of total mortality	Proportion of trees planted[2]	Proportion of total mortality
Drought	21.8	55.5	8.6	61.8
Physiologically weak[3]	5.8	14.9	2.0	14.6
Winterkill[4]	8.1	20.8	1.6	11.8
Frost heaving	.7	1.8	.08	.6
Missing	1.5	3.9	.16	1.1
Animal	.6	1.6	.55	3.9
Unknown	.6	1.5	.86	6.2
Total	38.8	100.0	13.8	100.0

[1] 1,600 trees.

[2] 1,280 trees.

[3] Trees that did not grow.

[4] Includes all trees that died during the first winter.

Eighty-six percent of the trees were still alive after two growing seasons at A-1 Mountain, with survival ranging from 70 to 96 percent for the various treatments (table 2). Survival was significantly better on scalped than on unscalped plots, but there was no significant difference between scalping treatments. Survival of trees planted to a standard depth with a three-rock mulch was significantly better than that of trees planted by the other three methods, regardless of scalping treatment, except that trees planted in completely scalped plots survived equally well, regardless of planting methods.

Drought was the most important cause of mortality at A-1 Mountain; it accounted for 62 percent of all losses (table 1). About 15 percent of the losses were attributed to poor physiological condition of the stock, and 12 percent to winterkill. Gophers caused about 4 percent of total mortality.

DISCUSSION

Despite one of the driest summers on record, initial survival at A-1 Mountain was excellent. At Jones Mountain, survival was acceptable except for losses caused by competition from grasses.

Precipitation during the summer of 1960 was subnormal especially for the critical months of June and July (table 3). Rainfall for the 2 months at A-1 Mountain was less than one-fourth of the long-term average and less than one-third at Jones Mountain.

Reduced survival at Jones Mountain in comparison with A-1 Mountain is attributed to competition from planted grasses. When trees were planted in April, little herbaceous vegetation was evident at Jones Mountain; by midsummer, however, a luxuriant stand of grass covered the area (fig. 2).

Table 2.--Percent survival by scalping treatment and planting method at A-1 Mountain after two growing seasons

Planting method[1]	Scalping treatment				Average
	Check	16-inch spots	26-inch spots	Complete	
	Percent				
Standard; no mulch	70	84	90	94	84
Standard; mulch	91	96	94	95	94
Deep; no mulch	72	78	84	91	81
Deep; mulch	71	82	94	91	84
Average	76	85	90	93	86

[1] Standard: Root collar at ground line.
Deep: Terminal bud at ground line.
Mulch: Three rocks around stem.

Figure 2.--Stand of orchardgrass (Dactylis glomerata L.) at Jones Mountain, 1961, 1 year after planting ponderosa pine.

Table 3.--Comparison of rainfall at Jones Mountain and A-1 Mountain during period April-September 1960, with 50-year average (1909-58) at Fort Valley Experimental Forest

Period compared		Jones Mountain	A-1 Mountain	Fort Valley Experimental Forest
		----- Inches -----		
April	1-15	0.83	0.73	--
	16-30	.12	.82	--
		.95	1.55	1.47
May	1-15	1.81	.84	--
	16-31	.00	.06	--
		1.81	.90	.78
June	1-15	.34	.29	--
	16-30	.00	.00	--
		.34	.29	.67
July	1-15	.08	.27	--
	16-31	.59	.28	--
		.67	.55	3.04
August	1-15	.87	1.79	--
	16-31	2.28	1.55	--
September	1-15	1.16	2.44	--
	16-30	.13	.00	--
		1.29	2.44	1.81

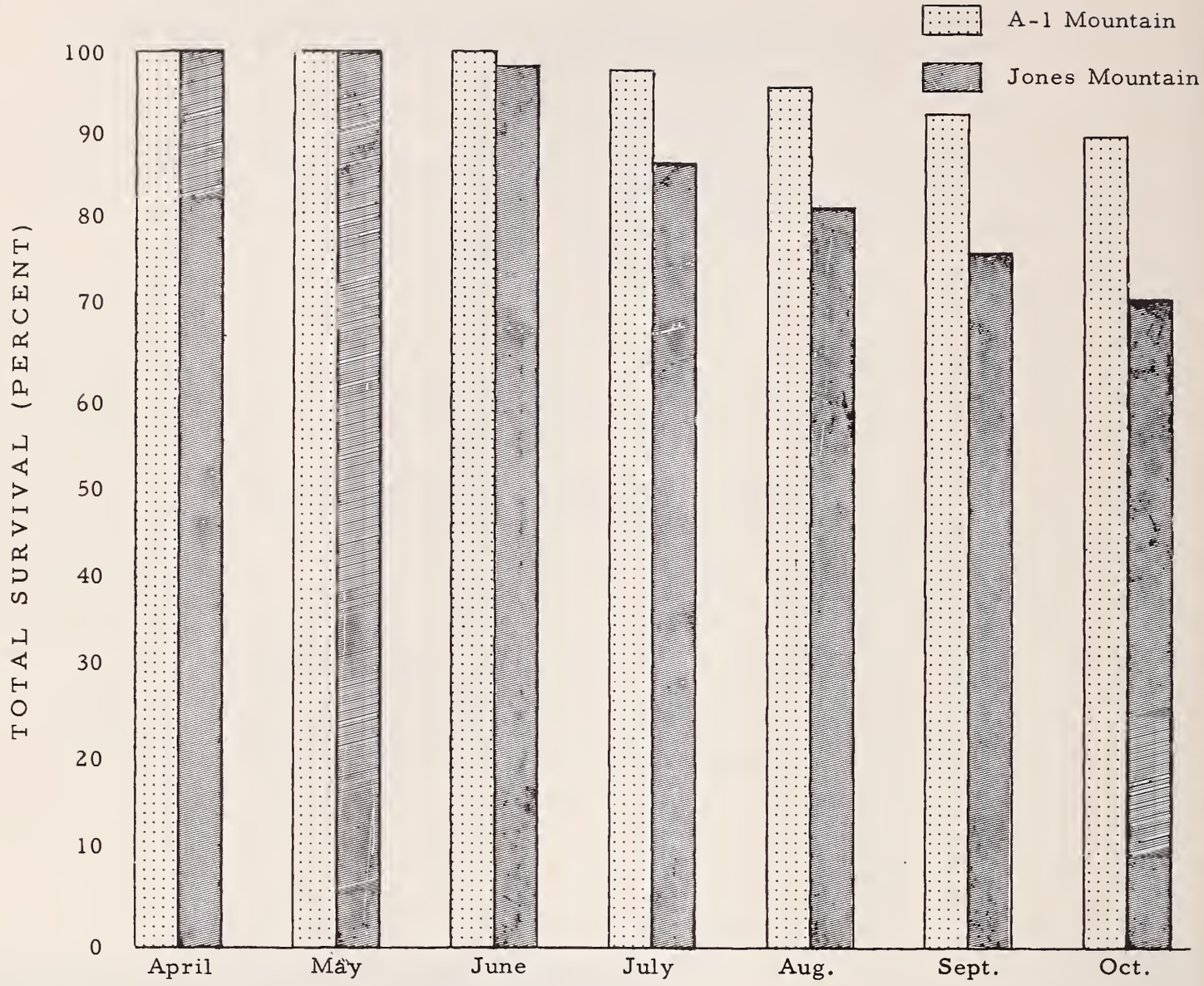

Figure 3.--Average monthly survival of ponderosa pine transplants at Jones Mountain (October survival estimated) and A-1 Mountain during the first growing season.

Mortality was negligible until July (fig. 3), when the seeded grasses were growing vigorously and drought conditions had existed for several weeks.

Survival was good on grass-free areas at Jones Mountain. For example, 29 of 31 trees on a fire road were alive and in good condition the second summer. Baron (1962) found in California that, when ponderosa pine is planted a year after grass is seeded, mortality is considerably higher than when the two are introduced at the same time. Mortality is reduced still further when no grass is seeded.

Total mortality was almost three times as high at Jones Mountain as at A-1 Mountain. Although it is not possible to compare the two plantations statistically, some pertinent observations may be made. At Jones Mountain competition was mainly from seeded grasses that grew actively during the spring dry period. At A-1 Mountain the cover was a mixture of brush, grass, and weed species. The grass was mainly mountain muhly, which does not begin active growth until the summer rainy period. Mortality at A-1 Mountain began later in the first summer than at Jones Mountain and was not so severe (fig. 3).

A large percentage of the trees at Jones Mountain were browsed by deer and elk; a few trees were chewed by rabbits at A-1 Mountain. Deer repellents were applied to the transplants at Jones Mountain, but too late to be effective. Although little mortality at Jones Mountain was attributed directly to animals, trees were undoubtedly weakened so that they were much more susceptible to drought and winterkill.

Many small trees died at each plantation. Diameter at the root collar of measured dead transplants at Jones Mountain, A-1 Mountain, and two other plantations in 1961 averaged only 0.17 inch. Very few dead seedlings had diameters greater than 3/16 inch. Clark and Phares (1961) and Klawitter (1961) have emphasized the danger of planting small stock.

A mulch of three rocks helped to increase survival where vegetation was undisturbed, but influenced survival little where vegetation was completely eliminated.

CONCLUSIONS

Adherence to the following practices should improve planting success of ponderosa pine in the Southwest:

1. Use only large planting stock--at least 0.19 inch in diameter at the root collar and a well-developed root system at least 8 inches long.
2. Destroy competing vegetation.
3. Handle planting stock carefully at all stages from the nursery bed to the planting site so only truly live trees will be planted.
4. Protect all plantations from browsing by livestock and game animals.

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